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CONVERSION OF GFSK-MODULATED SIGNALS INTO QPSK-MODULATED SIGNALS

The present invention is directed to a mobile radiotelephone device and to a method for the wireless transmission of QPSK-modulated data upon employment of a DECT baseband controller.

The DECT standard was enacted at the start of the 1990's in order to replace the existing, different analog and digital standards in Europe. It is the first common European standard for cordless telecommunication. A DECT network is a micro-cellular, digital mobile radiotelephone network for high subscriber densities. It is mainly designed for use in buildings. An employment of the DECT standard outdoors, however, is likewise possible. The capacity of the DECT network of approximately 10,000 subscribers per square kilometer turns the cordless standard into an ideal access technology for network operators. Both the transmission of voice as well as the transmission of data signals is possible according to the DECT standard. Thus, cordless data networks can also be constructed on the DECT basis.

The DECT standard shall be described in greater detail below on the basis of Figure 2. A digital, cordless telecommunication system for ranges below 300 m was standardized for Europe under the designation DECT (Digital Cordless European Communication). In combination with the switching function of a telecommunication system, thus, this system is suitable for mobile telephone and data traffic in an office building or on a company campus. The DECT functions supplement a telecommunication system and thus turn it into the fixed station FS of the cordless telecommunication system. Digital radio connections between the fixed station FS and the maximum of 120 mobile stations MS can be set up, monitored and controlled on up to 120 channels.

Transmission is carried out in the frequency range 1.88 GHz through 1.9 GHz on a maximum of ten different carrier frequencies (carriers). This frequency-division multiplex method is referred to as FDMA (Frequency Division Multiple Access).

The data in the DECT standard are modulated according to the GMSK method (Gauss Minimum Shift Keying).

Twelve channels are transmitted in chronological succession in the time-division multiplex method TDMA (Time Division Multiple Access) on each of the twelve carrier frequencies. A total of 120 channels thus derive for the cordless telecommunication according to the DECT standard given ten carrier frequencies and respectively twelve channels per carrier frequency. Since, for example, one channel is required for each voice connection, 120 connections to a maximum of 120 mobile stations MS derive. Work on the carriers is in alternating mode (duplex, TTD). After the twelve channels (channels 1-12) have been sent, a switch is made to reception and the twelve channels (channels 13-24) are received in the opposite direction.

A time-division multiplex frame is thus composed of 24 channels (see Figure 2). Channel 1 through channel 12 are thereby transmitted from the fixed station FS to the mobile station MS, whereas channel 13 through channel 24 are transmitted in the opposite direction from the mobile station MS to the fixed station FS. The frame duration amounts to 10 ms. The duration of a channel (time slot, slot) amounts to 417 μs. In this time, 320 bits of information (for example, voice) and 100 bits of control data (synchronization, signalling and error monitoring) are transmitted. The payload bit rate for a subscriber (channel) derives from the 320 bits of information within 10 ms. It thus amounts to 32 kilobits per second.

In addition to the aforementioned 320 information bits, each time slot in the DECT standard contains another 104 bits required for the signal transmission as well as 56 bits of a guard field, so that each time slot contains a total of 480 bits.

For countries outside Europe, the DECT standard may have to be potentially modified and adapted to the local conditions. For example, in the USA the transmission cannot ensue in the normal DECT range between 1.88 and 1.90 GHz; on the contrary, the generally accessible 2.4 GHz ISM band (Industrial, Scientific and Medical) is available. Further, modifications must be undertaken for adaptation to the national regulations such as, for example, the American regulation FCC part 15. Said American regulation describes the transmission methods, transmission powers and the available bandwidth that are allowed for the air interface. A use of DECT is not

allowed in this band since the bandwidth of DECT (1.2 MHz) exceeds the allowable bandwidth of 1.0 MHz.

Over and above this, how much transmission power is allowed to be transmitted on a specific channel during a specific time duration is prescribed in FCC part 15. This regulation would also not be satisfied by a direct transfer of the DECT standard.

One possibility for realizing an air interface that satisfies said rules is comprised in the employment of a higher-grade modulation method, for of a QPSK-based system wherein the carrier frequency is changed at predetermined time intervals (Frequency Hopping Spread Spectrum). For example, the employment of the higher-grade modulation method halves the required bandwidth given employment of a QPSK system.

One problem thereby arises when controller ICs that exist for the cost-beneficial realization of the air interface and that are designed for the DECT standard are to be employed since, as known, the data in the DECT standard are modulated onto the carrier frequency according to a GFSK (Gauss Frequency Shift Keying) system.

The object of the present invention is therefore to offer a mobile radiotelephone device and a method that make it possible to create a QPSK air interface upon employment of an existing DECT controller.

This object is achieved by the features of the independent claims. The dependent claims develop the central idea of the invention in an especially advantageous way.

According to the invention, thus, a mobile radiotelephone device is provided for the wireless transmission of QPSK data. The mobile radiotelephone device thereby comprises a controller that is designed and developed for a transmission of GFSK-modulated data, for example according to the DECT standard. According to the invention, an adaptor module is provided that converts GFSK-modulated data output by the controller into QPSK-modulated data to be transmitted or, respectively, converts the received QPSK-modulated data into GFSK-modulated data and gives them to the controller.

The adaptor module must thereby be designed such that is assures a synchronization of the QPSK-modulated data after the conversion of the QPSK-modulated data into GFSK-modulated data according to the DECT standard, which can ensue with a synchronization signal from the adaptor module to the controller.

The adaptor module can thereby drive an RF module such that the data are modulated onto a carrier frequency FX that lies outside the DECT band. For example, the carrier frequency can lie in a 2.4 GHz band (ISM band).

The adaptor module can be implemented with an ASIC.

The adaptor module can convert GFSK-modulated data into $\pi/4$-QPSK-modulated data or, respectively, received $\pi/4$-QPSK-modulated data into GFSK-modulated data.

According to the invention, further, a method is provided for the wireless transmission of QPSK-modulated data with a controller that is designed for a transmission of GFSK-modulated data, for example according to the DECT standard. An adaptor module thereby converts GFSK-modulated data output by the controller into QPSK-modulated data to be transmitted or, respectively, converts received QPSK-modulated data into GFSK-modulated data and gives them to the controller.

According to the invention, the carrier frequency fx can be changed after a predetermined time duration, whereby the predetermined time duration can be a time sl,ot or a frame (or a multiple thereof) of the DECT time frame.

The invention shall now be explained in greater detail on the basis of an exemplary embodiment and with reference to the accompanying drawings. Shown are:

Figure 1 an inventive arrangement for the digital radio transmission of data;

Figure 2 a schematic illustration of the known DECT standard;

Figure 3 a phase state diagram of the QPSK modulation and

Figure 4 a state transition diagram of the $\pi/4$ DQPSK modulation;

Figure 5 a detailed illustration of a portion of an inventive mobile radiotelephone device;

Figure 6 a development of the device according to Figure 5 wherein a adaptor module forwards a synchronization signal to the controller.

An arrangement for the digital radio transmission of data is provided in Figure 1. A fixed station 1 is thereby connected to the fixed network with a terminal line 10. The fixed station 1 comprises an RF module 4 with which data can be transmitted or, respectively, received with an antenna 6.

A radio transmission to a mobile station 2 via a radio transmission link 8 or, respectively, a radio transmission to a mobile station (cordless telephone) 3 via a second radio transmission link 9 can ensue with the antenna 6. All mobile stations shown in Figure 1 have the same structure, so that a more detailed explanation shall only ensue with reference to the illustrated mobile station 2.

As can be seen in Figure 1, this mobile station 2 comprises an antenna 7 for the reception or, respectively, for the transmission of data from or, respectively, to the fixed station 1. An RF module 5 that essentially corresponds to the RF module 4 employed in the fixed station 1 is provided in the mobile station 2.

A modulator (referenced 20) is provided in the fixed station 1, the exact function thereof being explained later. A demodulator is referenced 21 in the mobile station 2, this implementing the inverse function with respect to that of the modulator 20. Moreover, it must be pointed out that, of course, the fixed station 1 as well as each mobile station 2, 3 respectively comprise a modulator and a demodulator, as known from radio transmission systems.

As already initially mentioned, the present invention is intended to create a possibility of an air interface in order to adapt the known DECT standard to the regulations that apply to the American ISM band. The problem thereby arises that the baseband width of 1.2 MHz that are [sic] required according to the DECT standard for offering the bit rate of 1.152 megabits per second exceeds the maximum baseband width of 1 MHz prescribed by the American rule FCC part 15. A higher-grade modulation method is therefore employed. In the sense of the present specification, a high-grade modulation method (compared to the GMSK modulation method of the DECT standard) is a modulation method wherein more than two (i.e., 4, 8, ...) discrete carrier states are present and, thus, at least two bits are combined to form a symbol and are transmitted together as symbol in one step.

For example, quadrature phase shift keying QPSK (4 PSK), which is shown in Figure 3, is thus a higher-grade modulation method in this sense. According to the QPSK modulation method, the input data are offered as bipolar pulses, i.e. the logical 1 is represented by +1 and the logical 0 is represented by -1. With serial/parallel conversion, the serial data stream is first divided into bits of even-numbered and odd-numbered position. After this conversion, two data signals are present having respectively half the data rate of the original signal.

Another example of a higher-grade modulation method is the $\pi/4$ DQPSK modulation method shown in Figure 4. The goal of this modulation method is to avoid phase skips of 180° that lead to amplitude fades. To that end, respectively two bits are combined to form a symbol and effect a phase skip of ± 45° or ± 135° compared to the last transmission phase, as shown in the state transition diagram of Figure 4.

Let the 8 PSK or the 16 PSK modulation method be cited as further examples of higher-grade modulation methods, whereby 8 or, respectively, 16 discrete carrier states are present and, thus, 3 or, respectively, 4 bits are combined to form a symbol and are transmitted.

What all digital modulation methods have in common is that the transmission bandwidth becomes smaller with an increasing m, i.e. with an increasing plurality of carrier states, and given an unchanging bit rate, since, of course, $N=ld(m)$ bits are always combined to form a symbol and are transmitted as common symbol in a single step. In the present case, this means, that the bit rate of the DECT standard can be retained as a result of the higher-grade modulation method, and, at the same time, the transmission baseband width is smaller than the maximum value prescribed by FCC part 15. Due to the combining of at least two bits, for example, the baseband width can be halved given an unaltered bit rate.

Component parts developed and produced for the DECT standard such as, for example, the DECT baseband controller, can thereby continue to be cost-beneficially employed since the time slot and frame structure of the transmission is not modified compared to the DECT standard.

Parameters of the inventive air interface that can proven especially advantageous are compiled again below in the following table.

Frequency band	2.4 - 2.483 GHz ISM band
Transmission method	Frequency hopping spread spectrum
Access method	FDMA / TDMA
Duplex method	TDD
Number of carrier frequencies	96
Spacing of the carrier frequencies	0.864 MHz
Carrier frequencies (MHz)	f_n=2401.056+nx0, whereby n=0...95
Number of possible channels	1152
Number of channels that can be simultaneously occupied	12
Transmitted peak power	250 mW (up to 1 Watt possible)
Anticipated range	as in DECT (≈ 300 m)
Modulation method	2-level modulation, for example π/4SQPSK
Frame length	10 ms (5ms, Rx, 5ms Tx)
Number of time slots	24
Bit rate	1152 kbit/s

The sale of cordless telephones according to the DECT standard is currently essentially limited to European countries since the corresponding frequencies were released there. For an introduction into other countries such as, for example, the USA, the above-recited air interface according to the 2.4 GHz ISM band is, for example, required. In this case, of course, some parameters -- as explained above -- must be adapted in view of the rules (FCC part 15) that apply to this band. One possibility of doing this was explained above. The employment of existing DECT controller is advantageous for a cost-beneficial realization of such a system since economic advantages can be achieved due to the great piece numbers. Although, as mentioned above, the time slot and frame structure of the transmission need not be modified compared to the DECT standard, it must nonetheless be noted that a GFSK modulation method is employed according to the DECT standard and that there are no DECT systems that employed QPSK-based modulation methods.

According to the present invention, therefore, the functionality of a suitable module should be defined that makes it possible to convert signals of an existing DECT controller into QPSK-based systems (for example, PWT). This module can be realized, for example, in the form of an ASIC or in any other form. This module must thereby realize the following functions:

-- conversion of GFSK modulation into QPSK (for example, $\pi/4$-QPSK) modulation in the transmission case;

-- conversion of QPSK (for example, $\pi/4$-QPSK) modulation into GFSK modulation;

-- drive of the RF module with a corresponding frequency information, i.e.
  - -- conversion of the frequency drive of a DECT controller to the demands of the corresponding air interface, and
  - -- generation of the frequency information required by a DECT controller from the actual conditions.

The invention shall now be explained in detail with reference to Figure 5. Figure 5 shows a mobile radiotelephone device that can be a base station or a mobile station. As usual in a transmission according to the DECT standard, a DECT baseband controller 22 is thereby provided. Among other things, this baseband controller 22 comprises a modulator/demodulator. According to the invention, however, an additional adaptor module 23 is provided that, for example, can be realized by an ASIC.

According to the invention and as can be seen from Figure 5, the DECT baseband controller 22 forwards GFSK-modulated data to the ASIC 23 in the transmission status. This ASIC 23 converts the GFSK-modulated data into QPSK-modulated data and forwards them to the radiofrequency module 4, 5. The radiofrequency module 4, 5 then outputs these QPSK-modulated data to the antenna 6, 7. The baseband controller 22 is also connected to the adaptor module 23 with a control line 24 that serves for the DECT carrier setting.

When the transmission is to ensue in a frequency band other than the DECT frequency band, the ASIC 23 also forwards carrier frequency information f_x to the radiofrequency module 4, 5 with a control line 25 in order to modulate this onto

the corresponding carrier frequency. For example, a transmission in the ISM 2.4 GHz band can thus ensue.

Upon reception of QPSK-modulated date that the radiofrequency module 4, 5 gives to the ASIC 23 and that can also contain a synchronization word in addition to the payload data, the ASIC 23 also forwards synchronization information together with the actual payload data to the DECT baseband controller 22 GFSK-modulated.

As can be seen from Figure 6, the GFSK modulator/demodulator 20, 21 of the DECT baseband controller 22 forwards GFSK-modulated data to the ASIC 23 in the transmission condition. The ASIC 23 converts the GFSK-modulated data and gives them to the radiofrequency module 4, 5 of the DECT baseband controller. The radiofrequency module 4, 5 then outputs these QPSK-modulated data to the antenna 6, 7.

When the transmission is to ensue in a frequency band other than the DECT frequency band, the ASIC 23 also forwards carrier frequency information f_x to the radiofrequency module 4, 5 in order to modulate this onto the corresponding carrier frequency. For example, a transmission in the ISM 2.4 GHz band can thus ensue.

Upon reception of QPSK-modulated date that the radiofrequency module 4, 5 gives to the ASIC 23, the ASIC 23 also forwards synchronization information to the QPSK modulator/demodulator 20, 21 of the DECT baseband controller 22.

Given the illustrated arrangement, the problem can thereby arise that the synchronization method as employed in the DECT baseband controller 23 must continue to function, i.e. that the DECT controller must now synchronize to the data stream converted by the adaptor module 23. It must thereby be noted that the QPSK-modulated data are transmitted/received with half the data rate since one QPSK symbol corresponds to exactly 2 DECT bits. Some DECT bits can thus be lost upon reception, these being required by the DECT baseband controller 22 for the synchronization.

According to the present invention and as can be seen in Figure 6, the adaptor module 23 that realizes the conversion between the QPSK and the GFSK modulation method permanently transmits [sic] a DECT synchronization signal (1, 0

sequence) available to the DECT baseband controller 22 in its synchronized condition. The DECT baseband controller 22 can thus synchronize to this sequence of the DECT synchronization signal from the adaptor module 23.

A prerequisite therefor is that the adaptor module 23 can synchronize to the received QPSK signal (symbol synchronization). Given a modification of the time position of the synchronization as acquired by the adaptor module 23 on the basis of the received QPSK signal, the time position of the DECT synchronization signal that the adaptor module 23 outputs to the DECT baseband controller, correspondingly, is correspondingly [sic] adapted. Since, thus, only the synchronization word (DECT synchronization signal) need by slightly shifted in time, a fast synchronization can thus ensue in the "DECT level".

According to the present invention, thus, a cost-beneficial module can be created upon employment of a DECT baseband controller according to a QPSK modulation method.

List of Reference Characters

1:	fixed station
2:	mobile station (cordless telephone)
3:	mobile station
4:	RF module fixed station
5:	RF module base station
6:	Antenna fixed station
7:	antenna mobile station
8:	first radio transmission link
9:	second radio transmission link
10:	terminal line
20:	modulator
21:	demodulator
22:	baseband controller
23:	ASIC module
24:	control line
25:	control line
Zx:	time slots
f_x:	carrier frequency

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SPECIFICATION

TITLE

CONVERSION OF GFSK-MODULATED SIGNALS INTO QPSK-MODULATED SIGNALS

BACKGROUND OF THE INVENTION

Field of the Invention

1 The present invention is directed to a mobile radiotelephone device and to a method for the wireless transmission of QPSK-modulated data upon employment of a DECT baseband controller.

Description of the Related Art

2 The DECT standard was enacted at the start of the 1990's in order to replace the existing, different analog and digital standards in Europe. It is the first common European standard for cordless telecommunication. A DECT network is a micro-cellular, digital mobile radiotelephone network for high subscriber densities. It is mainly designed for use in buildings, but use of the DECT standard outdoors is likewise possible. The capacity of the DECT network of approximately 10,000 subscribers per square kilometer turns the cordless standard into an ideal access technology for network operators. Both the transmission of voice as well as the transmission of data signals is possible according to the DECT standard. Thus, cordless data networks can also be constructed on the DECT basis.

3 The DECT standard is described in greater detail below on the basis of Figure 2. A digital, cordless telecommunication system for ranges below 300 m was standardized for Europe under the designation DECT (Digital Cordless European Communication). In combination with the switching function of a telecommunication system, thus, this system is suitable for mobile telephone and data traffic in an office building or on a company campus. The DECT functions supplement a telecommunication system and thus turn it into the fixed station FS of the cordless telecommunication system. Digital radio connections between the fixed station FS and the maximum of 120 mobile stations MS can be set up, monitored and controlled up to 120 channels.

4 Transmission is carried out in the frequency range 1.88 GHz through 1.9 GHz on a maximum of ten different carrier frequencies (carriers). This frequency-division multiplex method is referred to as FDMA (Frequency Division Multiple Access).

5 The data in the DECT standard are modulated according to the GMSK method (Gauss Minimum Shift Keying).

6 Twelve channels are transmitted in chronological succession in the time-division multiplex method TDMA (Time Division Multiple Access) on each of the twelve carrier frequencies. A total of 120 channels thus derive for the cordless telecommunication according to the DECT standard given ten carrier frequencies and respectively twelve channels per carrier frequency. Since, for example, one channel is required for each voice connection, 120 connections to a maximum of 120 mobile stations MS derive. Work on the carriers is in alternating mode (duplex, TTD). After the twelve channels (channels 1-12) have been sent, a switch is made to reception and the twelve channels (channels 13-24) are received in the opposite direction.

7 A time-division multiplex frame is thus composed of 24 channels (see Figure 2). Channel 1 through channel 12 are thereby transmitted from the fixed station FS to the mobile station MS, whereas channel 13 through channel 24 are transmitted in the opposite direction from the mobile station MS to the fixed station FS. The frame duration is 10 ms. The duration of a channel (time slot, slot) is 417 μs. In this time, 320 bits of information (for example, voice) and 100 bits of control data (synchronization, signaling and error monitoring) are transmitted. The payload bit rate for a subscriber (channel) derives from the 320 bits of information within 10 ms, and is thus 32 kilobits per second.

In addition to the previously mentioned 320 information bits, each time slot in the DECT standard contains another 104 bits required for the signal transmission as well as 56 bits of a guard field, so that each time slot contains a total of 480 bits.

8 For countries outside Europe, the DECT standard may have to be potentially modified and adapted to the local conditions. For example, in the USA the

transmission cannot ensue in the normal DECT range between 1.88 and 1.90 GHz; on the contrary, the generally accessible 2.4 GHz ISM band (Industrial, Scientific and Medical) is available. Furthermore, modifications must be undertaken for adaptation to the national regulations such as the American regulation FCC part 15. This American regulation describes the transmission methods, transmission powers and the available bandwidth that are allowed for the air interface. A use of DECT is not allowed in this band since the bandwidth of DECT (1.2 MHz) exceeds the allowable bandwidth of 1.0 MHz.

9 In addition, FCC part 15 prescribes how much transmission power is allowed to be transmitted on a specific channel during a specific time duration. This regulation would also not be satisfied by a direct transfer of the DECT standard.

10 One possibility for realizing an air interface that satisfies these rules is to use a higher-grade modulation method, a QPSK-based system in which the carrier frequency is changed at predetermined time intervals (Frequency Hopping Spread Spectrum). For example, the employment of the higher-grade modulation method halves the required bandwidth when using a QPSK system.

11 One problem arises when controller ICs that exist for the cost-beneficial realization of the air interface and that are designed for the DECT standard are used since, as known, the data in the DECT standard are modulated onto the carrier frequency according to a GFSK (Gauss Frequency Shift Keying) system.

BRIEF SUMMARY OF THE INVENTION

12 The object of the present invention is therefore to offer a mobile radiotelephone device and a method that make it possible to create a QPSK air interface using an existing DECT controller.

13 This object is achieved by a mobile radiotelephone device for a wireless transmission of QPSK-modulated data, comprising: a controller (which may be a DECT controller) that is designed for a transmission of GFSK-modulated data, and an adaptor module that converts GFSK-modulated data output by the controller into

QPSK-modulated data to be transmitted or, respectively, that converts received, QPSK-modulated data into GFSK-modulated data and gives them to the controller. In this device, the adaptor module can be configured to output a synchronization signal to the controller in synchronized conditions. The adaptor module (which may be an ASIC) can be configured to synchronize to a received, QPSK-modulated signal. Furthermore, the adaptor module can time-shift the synchronization received signal for the controller dependent on its synchronization onto the QPSK-modulated signal. The inventive device may further comprise an RF module driven by the adaptor module such that the data are modulated onto a carrier frequency that lies outside the DECT band, such as the 2.4 GHz band. The adaptor module can be configured to convert GFSK-modulated data into pi/4 QPSK-modulated data or, respectively, converts received pi/4 QPSK-modulated data into GFSK-modulated data.

14 This object is also achieved by a method for the wireless transmission of QPSK-modulated data with a controller (which may be a DECT controller) that is designed for a transmission of GFSK-modulated data, comprising the step of converting, by an adaptor module, GFSK-modulated data output by the controller into QPSK-modulated data to be transmitted or, respectively, converting, by the adaptor module, received, QPSK-modulated data into GFSK-modulated data and gives the GFSK-modulated data to the controller. The adaptor model in this method can output a synchronization signal to the controller in a synchronized condition. A step of self-synchronizing by the adaptor module from a received, QPSK-modulated signal may be provided. In the method, the adaptor model may time-shift the synchronization signal for the controller dependent on its synchronization onto the QPSK-modulated signal. An RF module may be driven by the adaptor module such that the data are modulated onto a carrier frequency that lies outside the DECT band (e.g., 2.4 GHz). The adaptor module may convert GFSK-modulated data into pi/4 QPSK-modulated data or, respectively, convert received pi/4 QPSK-modulated data into GFSK-modulated data. The carrier frequency may be changed after a predetermined time duration (which may be a time slot or a frame of a transmission).

15 The invention is described below in greater detail.

16 According to the invention, thus, a mobile radiotelephone device is provided for the wireless transmission of QPSK data. The mobile radiotelephone device comprises a controller that is designed and developed for a transmission of GFSK-modulated data, for example, according to the DECT standard. According to the invention, an adaptor module is provided that converts GFSK-modulated data output by the controller into QPSK-modulated data to be transmitted, or that converts the received QPSK-modulated data into GFSK-modulated data and gives them to the controller.

17 The adaptor module must thereby be designed such that is assures a synchronization of the QPSK-modulated data after the conversion of the QPSK-modulated data into GFSK-modulated data according to the DECT standard, which can ensue with a synchronization signal from the adaptor module to the controller.

18 The adaptor module can drive an RF module such that the data are modulated onto a carrier frequency FX that lies outside the DECT band. For example, the carrier frequency can lie in a 2.4 GHz band (ISM band).

19 The adaptor module can be implemented with an ASIC, and can convert GFSK-modulated data into π/4-QPSK-modulated data, or received π/4-QPSK-modulated data into GFSK-modulated data.

20 According to the invention, furthermore, a method is provided for the wireless transmission of QPSK-modulated data with a controller that is designed for a transmission of GFSK-modulated data, for example, according to the DECT standard. An adaptor module converts GFSK-modulated data output by the controller into QPSK-modulated data to be transmitted, or converts received QPSK-modulated data into GFSK-modulated data and gives them to the controller.

21 According to the invention, the carrier frequency fx can be changed after a predetermined time duration, where the predetermined time duration can be a time slot or a frame (or a multiple thereof) of the DECT time frame.

BRIEF DESCRIPTION OF THE DRAWINGS

22 The invention is explained in greater detail on the basis of an exemplary embodiment and with reference to the accompanying drawings.

Figure 1 is a schematic block diagram of an inventive arrangement for the digital radio transmission of data;

Figure 2 is a schematic illustration of the known DECT standard;

Figure 3 is a phase state diagram of the QPSK modulation;

Figure 4 is a state transition diagram of the π/4 DQPSK modulation;

Figure 5 is a detailed block diagram illustrating a portion of an inventive mobile radiotelephone device; and

Figure 6 is a block diagram showing a development of the device according to Figure 5 in which an adaptor module forwards a synchronization signal to the controller.

DETAILED DESCRIPTION OF THE INVENTION

23 An arrangement for the digital radio transmission of data is provided in Figure 1. A fixed station 1 is connected to the fixed network with a terminal line 10. The fixed station 1 comprises an RF module 4 with which data can be transmitted or received with an antenna 6.

24 A radio transmission to a mobile station 2 via a radio transmission link 8 or a radio transmission to a mobile station (cordless telephone) 3 via a second radio transmission link 9 can ensue with the antenna 6. All mobile stations shown in Figure 1 have the same structure, so that a more detailed explanation only refers to the illustrated mobile station 2.

25 As can be seen in Figure 1, this mobile station 2 comprises an antenna 7 for the reception or, respectively, for the transmission of data from or, respectively, to the fixed station 1. An RF module 5 that essentially corresponds to the RF module 4 employed in the fixed station 1 is provided in the mobile station 2.

26 A modulator 20 is provided in the fixed station 1, whose exact function is explained below. A demodulator 21 (Figure 5) in the mobile station 2 implements the inverse function with respect to that of the modulator 20. Moreover, the fixed station 1 as well as each mobile station 2, 3 respectively comprise a modulator and a demodulator, as known from radio transmission systems.

27 As already initially mentioned, the present invention is intended to create an air interface in order to adapt the known DECT standard to the regulations that apply to the American ISM band. The problem is that the baseband width of 1.2 MHz that is required according to the DECT standard for offering the bit rate of 1.152 megabits per second exceeds the maximum baseband width of 1 MHz prescribed by the American rule FCC part 15. A higher-grade modulation method is therefore employed. In the sense of the present specification, a high-grade modulation method (compared to the GMSK modulation method of the DECT standard) is a modulation method in which more than two (i.e., 4, 8, ...) discrete carrier states are present and, thus, at least two bits are combined to form a symbol and are transmitted together as symbol in one step.

28 For example, quadrature phase shift keying QPSK (4 PSK), which is shown in Figure 3, is thus a higher-grade modulation method in this sense. According to the QPSK modulation method, the input data are offered as bipolar pulses, i.e., the logical 1 is represented by +1 and the logical 0 is represented by -1. With serial/parallel conversion, the serial data stream is first divided into bits of even-numbered and odd-numbered position. After this conversion, two data signals are present having respectively half the data rate of the original signal.

29 Another example of a higher-grade modulation method is the $\pi/4$ DQPSK modulation method shown in Figure 4. The goal of this modulation method is to avoid phase skips of 180° that lead to amplitude fades. To that end, respectively two bits are combined to form a symbol and effect a phase skip of ± 45° or ±135° compared to the last transmission phase, as shown in the state transition diagram of Figure 4.

30 The 8 PSK or the 16 PSK modulation method can be cited as further examples of higher-grade modulation methods, in which 8 or, respectively, 16 discrete carrier states are present and, thus, 3 or, respectively, 4 bits are combined to form a symbol and are transmitted.

31 What all digital modulation methods have in common is that the transmission bandwidth becomes smaller with an increasing m, i.e., with an increasing plurality of carrier states, and given an unchanging bit rate, since N=1d(m) bits are always combined to form a symbol and are transmitted as a common symbol in a single step. In the present case, this means, that the bit rate of the DECT standard can be retained as a result of the higher-grade modulation method, and, at the same time, the transmission baseband width is smaller than the maximum value prescribed by FCC part 15. Due to the combining of at least two bits, for example, the baseband width can be halved given an unaltered bit rate.

32 Component parts developed and produced for the DECT standard such as the DECT baseband controller, can continue to be cost-beneficially employed since the time slot and frame structure of the transmission is not modified compared to the DECT standard.

33 Parameters of the inventive air interface that can be proven especially advantageous are compiled again below in the following table.

Frequency band	2.4 - 2.483 GHz ISM band
Transmission method	Frequency hopping spread spectrum
Access method	FDMA / TDMA
Duplex method	TDD
Number of carrier frequencies	96

Spacing of the carrier frequencies	0.864 MHz
Carrier frequencies (MHz)	f_n=2401.056+nx0, whereby n=0...95
Number of possible channels	1152
Number of channels that can be simultaneously occupied	12
Transmitted peak power	250 mW (up to 1 Watt possible)
Anticipated range	as in DECT (. 300 m)
Modulation method	2-level modulation, for example π/4SQPSK
Frame length	10 ms (5ms, Rx, 5ms Tx)
Number of time slots	24
Bit rate	1152 kbit/s

34 The sale of cordless telephones according to the DECT standard is currently essentially limited to European countries since the corresponding frequencies were released there. For an introduction into other countries such as, for example, the USA, the above-recited air interface according to the 2.4 GHz ISM band is, for example, required. In this case, of course, some parameters -- as explained above -- must be adapted in view of the rules (FCC part 15) that apply to this band. One possibility of doing this was previously explained. The employment of an existing DECT controller is advantageous for a cost-beneficial realization of such a system since economic advantages can be achieved due to the great piece numbers.

Although, as mentioned above, the time slot and frame structure of the transmission need not be modified compared to the DECT standard, it must nonetheless be noted that a GFSK modulation method is employed according to the DECT standard and that there are no DECT systems that employed QPSK-based modulation methods.

35 According to the present invention, therefore, the functionality of a suitable module can be defined that makes it possible to convert signals of an existing DECT controller into QPSK-based systems (for example, PWT). This module can be realized, for example, in the form of an ASIC or in any other form. This module must realize the following functions:

- conversion of GFSK modulation into QPSK (for example, π/4-QPSK) modulation in the transmission case;
- conversion of QPSK (for example, π/4-QPSK) modulation into GFSK modulation;
- drive of the RF module with a corresponding frequency information, i.e.,
- conversion of the frequency drive of a DECT controller to the demands of the corresponding air interface, and
- generation of the frequency information required by a DECT controller from the actual conditions.

36 Figure 5 shows an inventive mobile radiotelephone device that can be a base station or a mobile station. As usual in a transmission according to the DECT standard, a DECT baseband controller 22 is provided. Among other things, this baseband controller 22 comprises a modulator/demodulator. According to the invention, however, an additional adaptor module 23 is provided that, for example, can be realized by an ASIC.

37 According to the invention and as can be seen from Figure 5, the DECT baseband controller 22 forwards GFSK-modulated data to the ASIC 23 in the transmission status. This ASIC 23 converts the GFSK-modulated data into QPSK-modulated data and forwards them to the radio frequency module 4, 5. The radio frequency module 4, 5 then outputs these QPSK-modulated data to the antenna 6,

7. The baseband controller 22 is also connected to the adaptor module 23 with a control line 24 that serves for the DECT carrier setting.

38 When the transmission is to ensue in a frequency band other than the DECT frequency band, the ASIC 23 also forwards carrier frequency information f_x to the radio frequency module 4, 5 with a control line 25 in order to modulate this onto the corresponding carrier frequency. For example, a transmission in the ISM 2.4 GHz band can thus ensue.

39 Upon reception of QPSK-modulated data that the radio frequency module 4, 5 gives to the ASIC 23 and that can also contain a synchronization word in addition to the payload data, the ASIC 23 also forwards synchronization information together with the actual payload data to the DECT baseband controller 22 GFSK-modulated.

40 As can be seen from Figure 6, the GFSK modulator/demodulator 20, 21 of the DECT baseband controller 22 forwards GFSK-modulated data to the ASIC 23 in the transmission condition. The ASIC 23 converts the GFSK-modulated data and gives them to the radio frequency module 4, 5 of the DECT baseband controller. The radio frequency module 4, 5 then outputs these QPSK-modulated data to the antenna 6, 7.

41 When the transmission is to ensue in a frequency band other than the DECT frequency band, the ASIC 23 also forwards carrier frequency information f_x to the radio frequency module 4, 5 in order to modulate this onto the corresponding carrier frequency. For example, a transmission in the ISM 2.4 GHz band can thus ensue.

42 Upon reception of QPSK-modulated date that the radio frequency module 4, 5 gives to the ASIC 23, the ASIC 23 also forwards synchronization information to the QPSK modulator/demodulator 20, 21 of the DECT baseband controller 22.

43 Given the illustrated arrangement, the problem can arise that the synchronization method as employed in the DECT baseband controller 23 must continue to function, i.e., that the DECT controller must now synchronize to the data stream converted by the adaptor module 23. The QPSK-modulated data are transmitted/received with half the data rate since one QPSK symbol corresponds to

exactly 2 DECT bits. Some DECT bits can thus be lost upon reception, these being required by the DECT baseband controller 22 for the synchronization.

44 According to the present invention and as can be seen in Figure 6, the adaptor module 23 that realizes the conversion between the QPSK and the GFSK modulation method permanently transmits a DECT synchronization signal (1, 0 sequence) available to the DECT baseband controller 22 in its synchronized condition. The DECT baseband controller 22 can thus synchronize to this sequence of the DECT synchronization signal from the adaptor module 23.

45 A prerequisite for this is that the adaptor module 23 can synchronize to the received QPSK signal (symbol synchronization). Given a modification of the time position of the synchronization as acquired by the adaptor module 23 on the basis of the received QPSK signal, the time position of the DECT synchronization signal that the adaptor module 23 outputs to the DECT baseband controller is correspondingly adapted. Since only the synchronization word (DECT synchronization signal) need be slightly shifted in time, a fast synchronization can thus ensue in the "DECT level".

46 According to the present invention, a cost-beneficial module can be created upon employment of a DECT baseband controller according to a QPSK modulation method.

47 The above-described method and device are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.